

# VLSI Implementation of Eye Detection System

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**Abstract**— The eye detection is one of the most challenging problems in many applications such as image processing, pattern recognition and computer vision. This paper introduces efficient vlsi implementation of eye detection system. Face detection is a very important part of the developed eye detection algorithm. Face detection is done by using skin detection method. Skin detection is an extraction of skin color pixels and regions from an image. In this method, first input image is converted from RGB image to YUV image. With YUV domain, the skin pixels in an image are extracted. Then Morphological operation is done by using erosion method through which noise of an image is also eliminated. From this image, face region is extracted by identifying the skin pixels. Then eye detection is done according to rules of human face proportion. The eye detection system is implemented using Verilog-HDL and simulation is done by using Xilinx ISE.

**Keywords**— Face Detection, Eye Detection, RGB, YUV.

## I. INTRODUCTION

Eye detection is one of the most challenging problems in disciplines such as image processing, pattern recognition and computer vision [1]. One of the major application for eye detection is iris detection. Other application of eye detection algorithm can be used in cell phone, security system, safe driving etc. Eye portion in an image is identified as low illumination, higher density edges, more contrast in comparison with rest part of the face. Face detection is a very important part of the developed algorithm. Face detection is done by using skin detection method [2]. Skin detection method is an extraction of skin color pixels and regions from an image.

Different approaches that are used to detect human faces are feature based, appearance based, and color based. The feature based method detects a human's face depends on human facial features [3]. Because of its complexity, this method requires lots of computing and memory resources. Color based method is more reasonable for applications that require low computational effort. In general, each method has its own advantages and disadvantages. More complex algorithm typically gives very high accuracy rate but also requires lots of computing resources [4]. Skin detection method is an effective method to detect face regions due to its low computational requirements and ease of implementation. Compared to the feature based method, the skin detection method required very little process [5]. This paper focuses on algorithm of the Eye Detection System by using Hardware Description Language.

Software used in this implementation is Xilinx Synthesis Tool version 14.1. XST comes with provision of implementing the design using hardware description language. Verilog HDL has been chosen as implementing language as it has some additional features in designing as well as verification. Isim simulator is used for functional simulation of the design. Functional simulation is done using test bench for each and every block individually. In the test benches, images are required to be given as an input. Input images are stored in a text file which contains all pixel values. Matlab 2014a is used to convert an image into text file so that the pixel values can be passed in the design. Verilog HDL does contain system task that can read a text file. Read text file can be loaded into a memory defined inside the design. Simulation result is observed in the waveform available in the Isim simulator. Test bench is also written using Verilog HDL.

## II. PROPOSED ALGORITHM

The input image is converted into text values using MATLAB program. Those values are stored in files and these are passed through test bench.

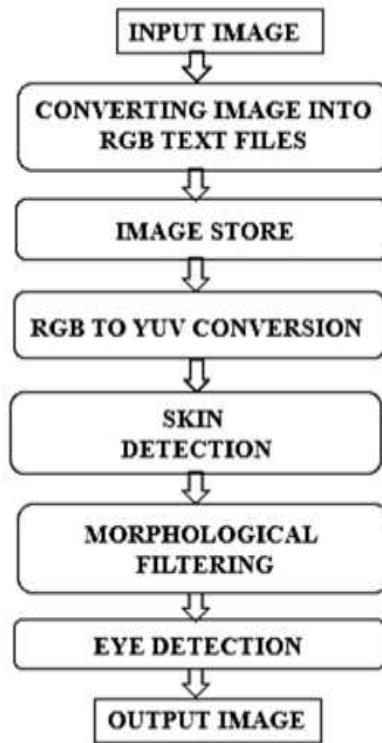


Fig. 1. Eye Detection System

To store the text file, memory is created. Then image is converted into luminance and chrominance domain to detect the skin pixels. Face is extracted using skin detection method. Then image is converted into a binary image. Morphological operation is performed to remove the unnecessary pixels. Horizontal location of eye is always at a fixed position with respect to face. Eye portion can be extracted by using face proportion rules to detect the status of eye. The flow chart of eye detection system is shown in Fig. 1.

#### A. Input Image

The Input image is taken in the form of three separate Red, Green and Blue (RGB) images. The RGB is an additive color model used to detect RGB values differently. The original image and RGB images are shown in Fig. 2.



Fig. 2(a). Original Image



Fig. 2(b). RGB Images

Fig. 2: Original Image and RGB Images

#### B. Converting Image into Text File

Matlab is used to convert an image into text file so that the pixel values can be passed into the Verilog. Matlab is capable of converting an image into text file with the help of predefined functions. Converted RGB text files are shown in Fig. 3.

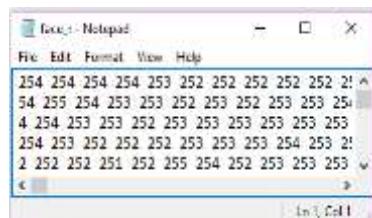


Fig. 3(a): Red Text File

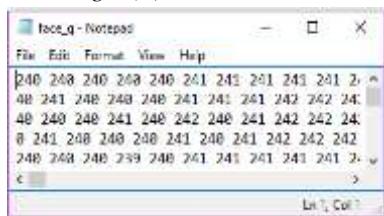


Fig. 3(b): Green Text File

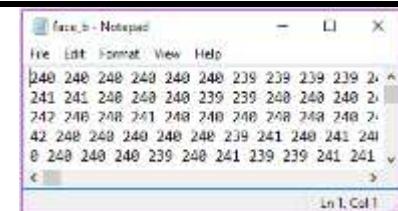


Fig. 3(c): Blue Text File

Fig. 3. RGB Text Files

The text file contains all pixel values of an image and when it is stored into test bench then only image processing will be done. After image is converted into text files, these files are stored in Verilog directory path because we can't read image directly in Verilog HDL. By seeing scroll bar in text file, can identify it as a large text file.

#### C. Reading a Large Text File using Verilog

In Verilog, to read a large text files and stored in to memory having two commands/functions. Where \$readmemh command is used to read the text files which consists of hexadecimal values and \$readmemb command is used to read text files which consists of binary values.

### III. FACE AND EYE DETECTION METHODS

#### I. FACE DETECTION METHOD

Skin detection is an important part of many applications such as face detection, face tracking, gesture analysis, bio-metric, surveillance, facial image coding compression, emotional computing, and face attribute classification and human computer interaction. To detect skin pixels, RGB image is converted into YUV image.

#### A. RGB to YUV Conversion

The RGB is an additive color model in which red, green, and blue colors are added together in various ways to produce a broad array of colors. In YUV color model, Y is Luminance, U and V are Chrominance blue and Chrominance red components. Luminance is very similar to the grayscale version of the original image. By YUV image, the skin color pixels clearly can be detected. The RGB to YUV Conversion is done by using the following equations.

$$Y = (R+2G+B) / 4$$

$$U = R - G$$

$$V = B - G$$

#### B. Skin Detection

The text files are created by using YUV image. The skin pixels can be segmented based on the following range

$$10 < U < 74$$

$$-40 < V < 11$$

In V range, skin pixels cannot be detected clearly so considering only U range. This stage detects skin pixels and converts it into binary image. Binary image contains black and white pixel where white pixels are taken for the face pixel and other pixel are kept as black so that it is easy to detect face region. Detection of skin pixel is done only with U component

where impact of other component was not participating much for skin pixel detection.

### C. Morphological Operation

In morphological operation, erosion method used to remove the redundant pixels. The original image is converted into black & white image and into text file. Morphological operation is performed to remove the redundant pixels which are available in any image. Morphological operation basically works with intended window of relevant shape moved all along the image to find and remove the redundant pixel. The intended window is termed as structuring element. Structuring elements is small binary image with pixels value of one's and zero's. Dimension of the structuring element gives the size of the structure element. Pattern of one's and zero's provides shape of the structuring element.

Erosion method has been done on the image to remove the residual pixels. Erosion process is mainly used for bringing shape of the image more precise by removing the redundant pixel. Here considering Diamond shaped  $3 \times 3$  element, shown in Fig. 4.

0	1	0
1	1	1
0	1	0

Fig. 4: Diamond shaped  $3 \times 3$  element

Checking each  $3 \times 3$  matrix, which will be taken from image if matches with diamond shaped  $3 \times 3$  element then centre element will become 1 or else 0. After checking each  $3 \times 3$  element, image gets ready without any noise produced in the background.

## II. EYE DETECTION METHOD

Eye portion is detected by using rules of human face proportions [6]. Position of eye with respect to the face is fixed for every normal face [7]. Ratio of human face proportion rules is shown in Figure 5.

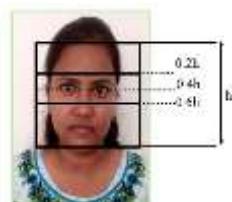


Fig. 5: Rules of Human Face Proportions

The eye portion is extracted from 0.2h to 0.6h from the whole face [8,9,10]. Extracted Eye portion is shown in Fig. 6. Eye extraction image is used to create the text file which contains eye pixels. The pixel range is then applied to detect eye portion of the face. According to the text file, eye status can be performed.

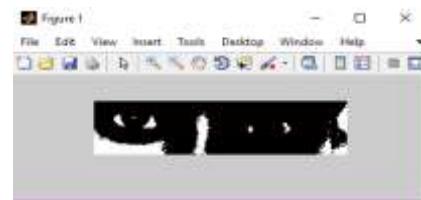


Fig. 6: Eye Extraction

## VI. RESULTS

The design is done using Verilog HDL and simulation is carried out in Xilinx ISE tool 14.1. Different Verilog construct such as behavioural, dataflow, gate level and structural modelling style are available for both design and verification. Design of the RTL diagram contains behavioural, dataflow, structural modeling style. Xilinx synthesis tool is used that converts RTL description in HDL to RTL design.

Simulated Output of RGB Pixels are shown in Fig. 7. For storing the RGB pixels, ram memory has been created. RAM memory consists of both read and write options. When read\_write option becomes one, it reads all the pixel values into input stages(red\_in, green\_in and blue\_in) and output stages(red\_out, green\_out and blue\_out) will be in an impedance state. This can be clearly seen in Fig. 7(a). When read\_write option becomes zero, it writes/stores all the pixels values into output stages(red\_out, green\_out and blue\_out). This can be clearly seen in Fig. 7(b). Simulated Output of RGB to YUV Conversion are shown in Fig. 8. In image, according to the U range the skin pixels are detected by producing one and zero in the output stage. Simulated Output of skin detection are shown in Fig. 9. According to the open and close text files, generating the eye status by producing one and zero in an output stage. If eye status output is one, its reading open eye image text file and eye status is open. If output is zero, it means its reading the close text file and eye status is closed. Simulated Output of Eye Detection is shown in Fig. 10.

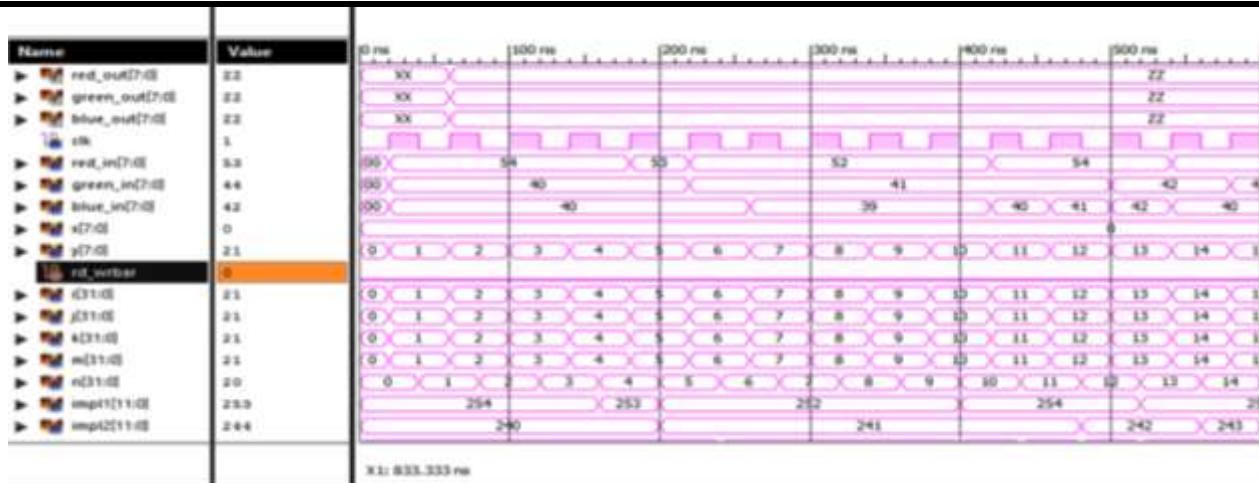


Fig. 7(a): Waveform of RGB Pixels when read write bar = 0

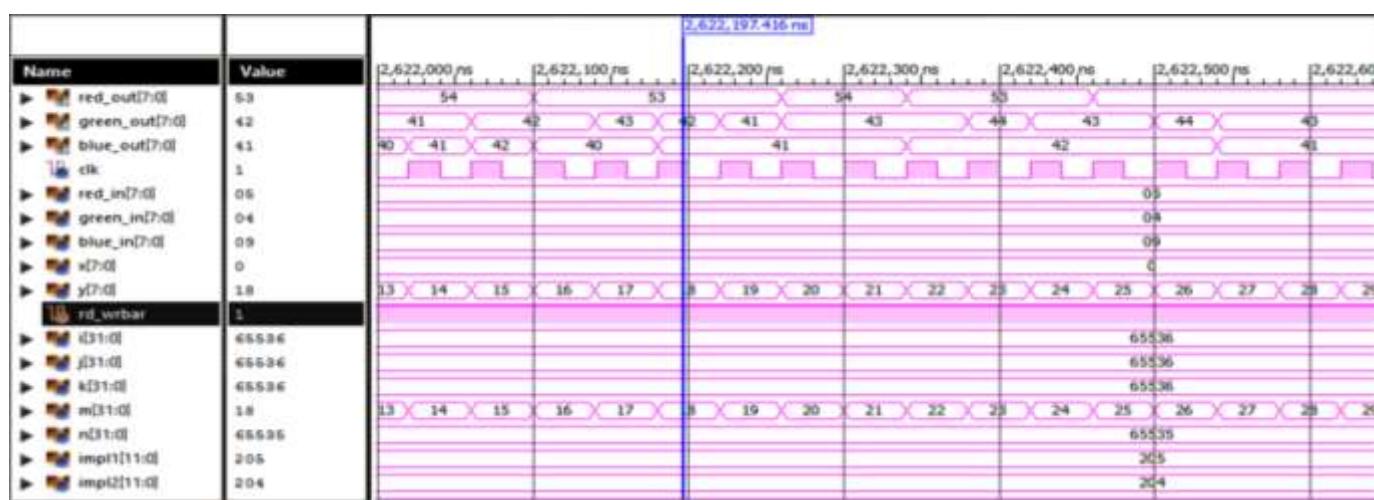


Fig. 7(b). Waveform of RGB Pixels when read write bar = 1

Fig. 7: Simulated Output of RGB Pixels

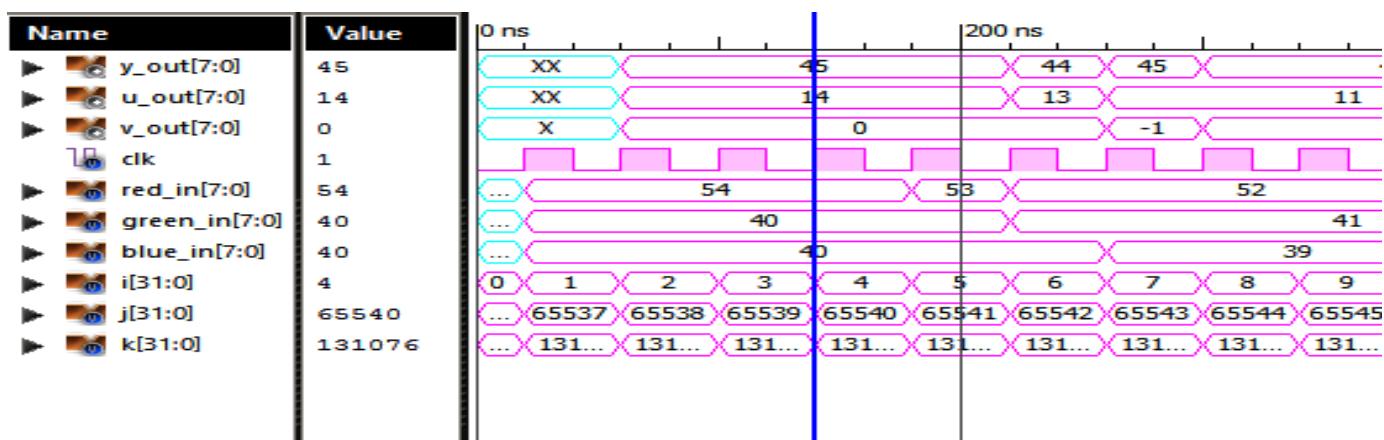


Fig. 8: Simulated Output of RGB to YUV Conversion

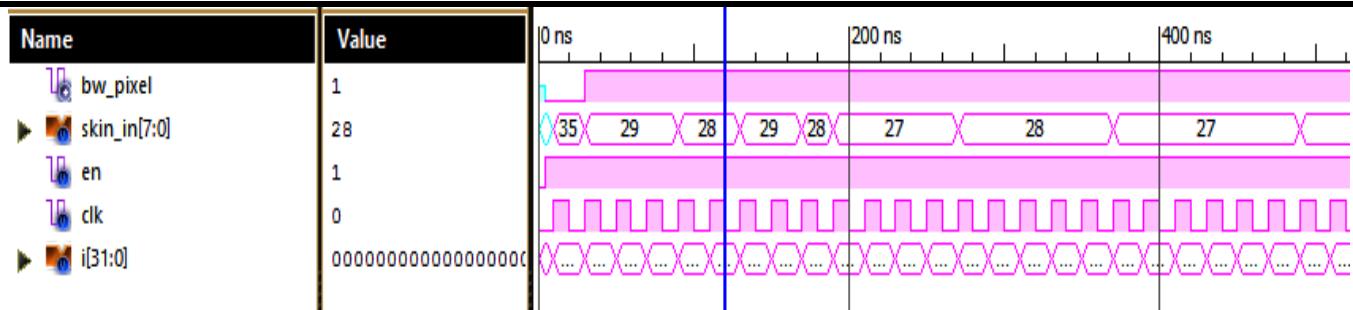


Fig. 9: Skin Pixels



Fig. 10: Eye Detection

## VII. CONCLUSION AND FUTURE SCOPE

This paper can be used in many applications such as gesture understanding, disabled-helping domain, and so on. Hence, this project has been successfully implemented using Matlab and Xilinx ISE tools.

Future work of this paper can be on FPGA's available in the market. Xilinx FPGA's are available in market that can be chosen for hardware implementation of proposed concept. Xilinx Spartan3, spartan3E, spartan6 are some of the FPGA that can be taken to implement it on the hardware level. Spartan series FPGA does have ample no. of gates to implement. Hardware implementation requires interfacing of physical memory to store image. As a real-time application, camera can be chosen as an input device to the design.

Moreover efficiency, power, operating frequency are the parameters which can be taken for making the system more enhanced. Although hardware implementation is a challenge but its Implementation gives better opportunities on research area in the field of image processing using ASIC design.

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